CHAPTER 1. AIR NAVIGATION AND COMMUNICATIONS

SECTION 4. CLASS II NAVIGATION

111. GENERAL.

A. This section provides concepts, direction, and guidance which shall be used by Federal Aviation Administration (FAA) inspectors to evaluate and approve or deny requests for authorization to conduct Class II navigation operations not previously approved for a particular operator. This section also amplifies the general concepts, direction, and guidance provided in section 1. Specific "standard practices" are provided in this section for evaluating Class II navigation operations using navigation systems which, within particular areas of en route operation, have well-known operational characteristics and limitations. When an operator requests approval to conduct Class II navigation using a means of navigation, or in areas not addressed by these standard practices, a request for direction and guidance must be forwarded through regional flight standards division (RFSD) to AFS-200.

B. Class II navigation is any en route flight operation or portion of a flight operation which is not Class I navigation. Any operation or portion of an en route operation which takes place outside (beyond) the officially designated operational service volumes of International Civil Aviation Organization (ICAO) standard navigational aids (NAVIAD) (VOR, VOR/DME, NDB) is Class II navigation. Additional information on the concept of Class II navigation is provided in sections 1 and 2. The various types of Class II navigation and the evaluation and approval or denial processes for these specific types are discussed in the following paragraphs.

113. VFR CLASS II NAVIGATION. VFR Class II navigation is any Class II navigation operation conducted under visual flight rules in VFR conditions (VMC in most foreign countries). The primary objectives of VFR Class II navigation and the navigational performance requirements are identical to the objectives and requirements for VFR Class I navigation. In addition, the types of VFR Class II navigation (pilotage and station-referenced) are identical to VFR Class I navigation. (See paragraphs 73 and 75)

A. The major difference between these two categories of VFR operation (Class II vs. Class I) are the navigation systems which must be used in certain special situations. For example, pilotage is not an acceptable means of conducting flight over desolate land areas or large bodies of water due to the absence of prominent landmarks. Therefore, VFR Class II navigation in these areas must use other navigational means. In addition, some navigation systems such as LORAN C have limited coverage and cannot be used for VFR Class II station-referenced operations in many areas of the world.

B. The factors which must be considered when approving VFR Class II navigation are essentially the same as VFR Class I navigation. Therefore, the direction and guidance in section 3 for approval of VFR Class I navigation shall be used for VFR Class II navigation approvals. When applying this direction and guidance, inspectors must evaluate the characteristics of the navigation system in the proposed area of operation and ensure that any ATC requirements unique to Class II navigation are met.

115. PART 135 AIRPLANE VFR CLASS II NAVIGATION STANDARD PRACTICES (TBD).

117. HELICOPTER VFR CLASS II NAVIGATION STANDARD PRACTICES (TBD).

119. IFR CLASS II NAVIGATION. IFR Class II navigation is any Class II navigation operation conducted under instrument flight rules. The primary generic IFR Class II navigation requirements are identical to the generic IFR Class I navigation requirements discussed in paragraph 85. However, in many cases, the means of navigation and the procedures/techniques necessary to satisfy these generic requirements are significantly different for IFR Class II navigation.

121. TYPES OF IFR CLASS II NAVIGATION. There are three generic types of IFR Class II navigation. These types are navigation by reference to ICAO standard NAVAID's supplemented by dead reckoning, navigation by use of pilot-operated electronic long-range navigation systems, and navigation by use of a flight navigator.

A. *ICAO Standard NAVAID's Supplemented by Dead Reckoning.* Sometimes, IFR Class II navigation requirements can be met using conventional NAVAID's (VOR, VOR/DME, and NDB) and special navigational techniques such as dead reckoning. IFR

Class II navigation using standard NAVAID's can only be conducted in areas where the air traffic control (ATC) lateral separation standards are large, 90 nautical miles (NM) or more.

(1) This type of IFR Class II navigation is based primarily on accurate dead reckoning with "reliable fixes" obtained periodically from VOR's, VOR/DME's and/or NDB's. IFR Class II navigation using ICAO standard NAVAID's supplemented by dead reckoning shall not be authorized if a reliable fix cannot be obtained for a period of more than 1 hour. Accurate dead reckoning requires that the following factors be accurate and reliable:

- Preflight planning
- Inflight planning
- Knowledge of upper air winds
- Aircraft heading information (within 2 degrees)
- Use of magnetic variation (grivation, if appropriate)
- Use of accepted dead reckoning navigation practices and procedures

(2) The major uncertainty in dead reckoning operations is the accuracy of upper air wind information (winds at altitude). Therefore, it is essential in these operations to accurately determine the actual wind (or drift correction) at specific locations and based on this known information, adjust the forecasted winds at other points along the route. This must be an ongoing process which uses the best available information to further refine the upper air wind information and adjust the aircraft's heading to account for changes in wind and magnetic variation (grivation if appropriate) to maintain the desired track. Navigational precision achieved by dead reckoning operations is directly related to the following factors:

- Flightcrew precision in accomplishing dead reckoning tasks
- Length of time between "reliable fixes"
- Accuracy of the navigation equipment used (VOR, VOR/DME, NDB)
- Accuracy of aircraft heading information
- Accuracy of the magnetic variation (grivation) used
- Magnitude of errors in determining the actual winds at flight altitude
- Latitude of the area of operation (higher latitude produces greater rhumb line vs. great circle errors)

(3) In this type of operation, the only practical way to establish the proper wind correction (drift angle) is to accurately track the outbound VOR radial (outbound course from NDB's) and establish the correction necessary to maintain route centerline. This wind correction must be compared to flight plan information to determine the necessary correction for subsequent legs. Usually, corrections determined in this manner remain reasonably accurate for periods of less than 1 hour and then only if there is no significant heading change en route between the NAVAID's used (that is, the course flown is a great circle between the NAVAID's).

B. *Pilot-Operated Electronic Long-Range Navigation Systems.* The vast majority of IFR Class II navigation operations are conducted using automatic pilot-operated electronic navigation systems. There are various types of automatic long-range navigation systems in use today. An automatic long-range navigation system must contain sensors which either detect motion or changes in geographic position and a computational capability which generates the guidance information necessary to adhere to the selected route centerline and determine arrival at selected waypoints. A system can consist of a single unit which combines these features or a combination of various sensors and computers such as the flight management system (FMS) in the B757/B767. Inertial, Doppler, and Omega navigation systems or combinations of these systems are the primary means of conducting IFR Class II navigation in most oceanic and remote land areas. Automatic Loran C navigation systems can also be used in certain limited areas of the northern hemisphere where reliable signal coverage exits. Space-based systems such as NAVSTAR Global Positioning System (GPS) are likely to provide highly accurate coverage over most of the world in the future. Sections 6 through 8 provide detailed discussion, guidance and direction related to the specifics of each of these systems. This section provides general direction and guidance which is appropriate to all automatic pilot-operated electronic long-range navigation systems. The basic types of automatic long-range navigation systems are described in the following subparagraphs.

(1) Inertial Navigational Systems (INS)

(a) INS functions as a high precision dead reckoning device. It is not a "position fixing" device. It is self-contained and does not depend on input from sources external to the aircraft. The initial geographic position must be inserted by a crewmember (alignment). The inertial sensors detect aircraft movement by measuring acceleration and velocity. These factors are applied to the initial position to calculate subsequent changes in position. These sensors can detect changes in velocity as small as 1 or 2 nautical miles per hour.

(b) Since INS is not a "position fixing" device, it does not have the ability to detect position errors. Errors induced while inserting the initial position can remain undetected by the system. If such errors are made, navigational guidance from the system will be erroneous throughout the flight unless the errors are detected and corrected by the flightcrew. INS errors are time dependent. That is, they increase with time (typically 1 NM to 2 NM per hour). The major limitations associated with INS are related to sensor inaccuracies, the dependence on proper alignment by the flightcrew, and the increase in error as flight time increases.

(2) *Doppler Navigation Systems (DNS).*

(a) DNS is a dead reckoning device; it is not a "position fixing" device. DNS detects aircraft velocity through changes in the radar signal reflected from the earth's surface using a phenomena called doppler shift or the doppler effect. Most doppler systems require input from the aircraft's compasses and as a result doppler systems are usually much less accurate than INS. Since DNS requires aircraft compass input they cannot be used in areas of magnetic unreliability unless special navigational techniques such as free gyro or grid are used.

(b) Special monitoring and compensation techniques must also be used with DNS to navigate to the degree of accuracy required for the control of air traffic. However, even when these special techniques are used, doppler systems cannot be used unless "reliable fixes" are obtained from ICAO standard NAVAID's at least once each 800 NM of flight or the DNS is frequently updated from another approved long-range navigation system such as an Omega Navigation System (ONS). Typical errors in a properly maintained and compensated DNS are 2 degrees or approximately 10 NM for each 300 NM of flight. The major limitations of Doppler systems are inaccuracies due to compass input, magnetic variation estimates, and velocity measurement errors. For these reasons DNS errors are time and distance dependent, that is, the error increases as flight time and flight distance increases.

(3) *Omega Navigation System (ONS).*

(a) An ONS functions as a "position fixing" device. It is referenced to signals from ground-based stations. An ONS is usable only within areas where signal quality and signal coverage meet certain standards. The accuracy of ONS can be affected by noise sources and signal irregularities. Most makes of Omega systems require input from the aircraft compasses, therefore an ONS cannot be used in areas of magnetic unreliability unless special navigational techniques such as free gyro or grid are used. To use an ONS, the initial geographic position and the precise time (Coordinated Universal Time (UTC)) must be entered into the system (initialization).

(b) The ONS detects changes in position through changes in the signal as the aircraft moves. Errors in entering the initial position and/or time can remain undetected by the system. If such errors are made, the navigation guidance will be erroneous throughout the flight unless these errors are detected and corrected by the flightcrew. An ONS cannot reliably detect position errors greater than approximately 8 NM's. When an error greater than 8 NM's occurs, this error is either retained (8 NM offset) or the cause of the error such as a solar disturbance reoccurs which then produces even greater errors. ONS errors are not flight time dependent. ONS errors are dependent on signal quality, signal strength, and signal geometry (typical ONS errors are 2 NM to 4 NM). The major limitations of ONS are related to susceptibility to signal disturbance, limitations in signal coverage, and dependence upon aircraft compass input.

(4) *LORAN C Navigation Systems.*

(a) An automatic LORAN C navigation system is a "position fixing" device. LORAN C navigation systems detect the aircraft's geographic position through measurements of the signals transmitted from ground-based stations. If usable signals can be received from at least four separate ground-based stations (three lines of position(LOP)), position ambiguity can be detected and automatically resolved by the navigation system. Since LORAN C is station-referenced, its accuracy can be affected by noise sources and signal irregularities. Since most automatic LORAN C navigation systems depend upon aircraft compass input, LORAN C cannot be used in areas of magnetic unreliability unless special navigation techniques such as free gyro or grid are used.

(b) The accuracy of LORAN C is not flight time dependant. The accuracy of these systems is dependent on the signal quality, signal strength, and signal geometry (typical errors are less than 1 NM). The major limitation to the use of LORAN C systems is inadequate signal coverage in most areas of the world. LORAN C coverage is nonexistent in the southern hemisphere and only limited coverage exists in the northern hemisphere.

(5) Space-Based Navigation Systems (NAVSTAR GPS)

(a) Although not currently operational for civil use (1988), NAVSTAR GPS (or future equivalent) is expected to be used as the navigation system of the future. NAVSTAR GPS is a three-dimensional "position fixing" device. GPS determines the aircraft's geographic position and absolute altitude (referenced to the center of the earth) through measurement of the signals received from satellites. The position calculated by the systems is expected to be very accurate. This space-based system is expected to provide world-wide coverage and is expected to provide sufficient accuracy to permit the system to be used for Class I and Class II navigation. The accuracy available to civil users is expected to be on the order of several hundred meters.

(b) The major limitation of these systems is expected to be related to loss of accuracy in some areas due to satellite failure. This accuracy degradation would exist until a new satellite is positioned to replace the failed unit.

C. *Flight Navigator.* Although flight navigators were extensively used in the past, technological improvements (INS, ONS) and higher levels of required navigation precision have limited the use of flight navigators. However, in many oceanic areas, flight navigators can still be used to meet IFR Class II navigation requirements. Flight navigators can also be used, in lieu of the pilots, to operator electronic long-range navigation systems such as INS or ONS.

123. IFR CLASS II NAVIGATION APPROVALS. General direction and guidance on air navigation approvals are in sections 1 and 2. Specific direction and guidance for approving IFR Class II navigation is discussed in the following subparagraphs and sections of this chapter.

A. *Degree of Accuracy Required.* Inspectors must determine that the navigation equipment and operational procedures/techniques used permit reliable IFR Class II navigation to the degree of accuracy required for the control of air traffic. See paragraph 11. The degree of accuracy required for any IFR Class II navigation operation must provide for the following criteria:

- Meets regulatory requirements
- Meets the standard practices in this handbook
- Meets the requirements of Part B of the operations specifications
- Provides accepted, safe operating practices
- Permits the safe separation of aircraft
- Assures obstacle avoidance along the route of flight
- Assures-adequate protection for persons and property on the ground
- Permits reliable navigation to the intended destination and any necessary alternate or diversionary airports

B. *Airworthiness of Navigation Equipment.* Inspectors must determine that any required navigation equipment is airworthy for IFR flight and installed in accordance with approved data. The operator must provide written evidence which shows that any navigation system used for IFR Class II navigation meets these requirements. If the operation involves flight into NAT/MNPS airspace, Canadian MNPS airspace, or areas of magnetic unreliability the operator must also provide evidence that the installed equipment is airworthy for these special areas of operations.

C. *Class II navigation Using ICAO Standard NAVAID's Supplemented by Dead Reckoning.*

(1) IFR Class II navigation using ICAO standard NAVAID's (VOR, VOR/DME, NDB) supplemented by dead reckoning *shall not* be approved for operations in the following areas:

- NAT/MNPS airspace
- Canadian MNPS airspace
- Areas of operation where the separation minimum are based on the use of VOR, VOR/DME (standard domestic separation)
- Areas of operation where the aircraft cannot be "reliably fixed" at least once each hour using non-visual NAVAID's
- Areas of magnetic unreliability unless the flightcrew is properly qualified for the special equipment/procedures to be used and the aircraft is suitably equipped for operations without magnetic reference

(2) The following criteria must be met for any approvals of IFR Class II navigation using ICAO standard NAVAID's supplemented by dead reckoning:

(a) Route segments must be great circle routes between NAVAID's.

(b) Positive course guidance must be available from the NAVAID's at each end of the great circle route segment.

(c) Operations over routes outside the operational service volumes must not exceed 1 hour flight time. Positive course guidance provided by the

NAVAID's must also be available at least once each hour.

(d) The routes or areas of operation to be approved must realistically permit the certificate holder to consistently dead reckon to the degree of accuracy required for the control of air traffic. The amount of flight time without positive course guidance (the dead reckoning period) is a factor that must be considered. Usually dead reckoning periods which exceed 15 minutes require an air traffic control (ATC) lateral separation of 90 NM or more.

(e) The areas of operation to be approved must not affect the accuracy or reliability of the systems providing heading information such as areas of magnetic unreliability.

D. *Pilot-Operated Electronic Long-Range Navigation Systems*.

(1) Pilot-operated electronic long-range navigation systems are required for all IFR Class II navigation operations which are conducted over routes or portions of routes where "reliable fixes" cannot be obtained at least once each hour. Unless the use of a flight navigator is approved, pilot-operated, electronic long-range navigation systems are the only means by which the IFR Class II navigation requirements can be met when a "reliable fix" at least once each hour cannot be obtained. Sometimes the FAA can also require the use of these long-range navigation systems over other routes even when "reliable fixes" can be obtained more frequently. In certain special areas of operation which require high levels of navigational performance the use of a flight navigator is not appropriate and pilot-operated, electronic long-range navigation systems must be used. (See section 5) These systems must be used for all operations in the following areas:

- NAT/MNPS airspace
- Canadian MNPS airspace
- Central East Pacific airspace where composite separation is applied
- North Pacific airspace where composite separation is applied
- Any other area where positive course guidance must be continuously available (or available more often than once each hour) to provide the level of navigation performance necessary for the control of air traffic

(2) All pilot-operated electronic long-range navigation systems require the use of special navigation procedures/techniques.

NOTE: All IFR Class II navigation operations using pilot-operated, electronic long-range navigation equipment shall use the practices and procedures recommended in AC 90-79 (or equivalent procedures). Inspectors must determine that these practices and procedures are included in the certificate holder's approved training programs and operating procedures.

E. *Flight Navigator.* Except when the flight navigator is used to operate electronic long-range navigation equipment, in lieu of the pilots, operations with a flight navigator shall not be approved for operations in the following areas:

- NAT/MNPS airspace
- Canadian MNPS airspace
- Central East Pacific airspace where composite separation is applied
- North Pacific airspace where composite separation is applied
- Any other area where positive course guidance must be continuously available (or available more often than once each hour) to provide the level of navigation performance necessary for the control of air traffic

125. CLASS II NAVIGATION USING ICAO STANDARD NAVAID's SUPPLEMENTED BY DEAD RECKONING STANDARD PRACTICES (TBD).

127. PILOT-OPERATED ELECTRONIC LONG-RANGE NAVIGATION SYSTEMS STANDARD PRACTICES (TBD).

129. FLIGHT NAVIGATOR STANDARD PRACTICES (TBD).

131. CONFIRMATION OF SYSTEM ACCURACY AND RELIABILITY (TBD).

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